Stinger: Geotechnical Tool for Small Planetary Rovers. K. Zacny[1], Z. Mank[1] J. Atkinson[1], C. Hyman[1], A. Rogg[2], M. Bualat[2], T. Fong[2]
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Introduction: Achieving flawless operation of surface mobility systems, excavation, mining, In-Situ Resource Utilization (ISRU) operations, and regolith transport depends on knowledge of geotechnical soil properties. Knowing soil strength and its density (and in turn fundamental soil parameters: friction angle and apparent or true cohesion) dictates the design of the wheels and excavation systems, and helps determine anticipated excavation power, forces, etc.

Soil physical properties may also be used to help interpret surface geologic processes and to constrain the origins and formation processes of the soils. For example, geological examination of the near subsurface increases our understanding of the formation and history of a geologic unit, a moon, or even a planet.

There are many historical instances indicating that the lack of geotechnical soil properties could have, or in fact had, severely affected or even ended missions. For example, Mars Exploration Rover (MER) Opportunity became stuck in a "sand trap" but was eventually able to free itself (Figure 1). MER Spirit also became trapped and never managed to drive off. The mission subsequently ended.

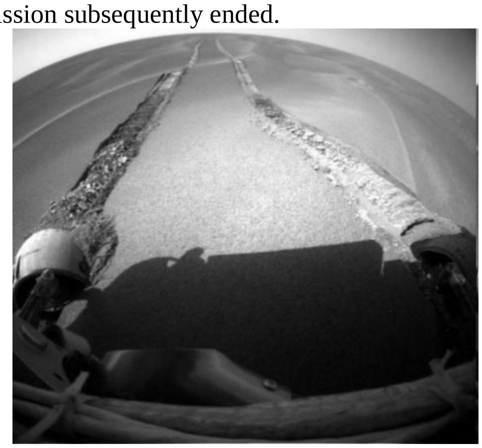

Figure 1. MER Opportunity stuck in 2005.

Stinger: Stinger is a robotic geotechnical instrument that combines an Apollo-based penetrometer approach for measuring bearing strength to 50 cm depth with a Lunokhod approach for measuring shear strength at the surface (Figure 2). The shear vane is initially housed inside the cone and is pushed out whenever shear tests are required. When the shear vane is out, the cone-vane is rotated to measure the shear strength of the soil. Upon completion of the shear measurement, the shear vane is pulled back into the cone and the cone proceeds deeper.

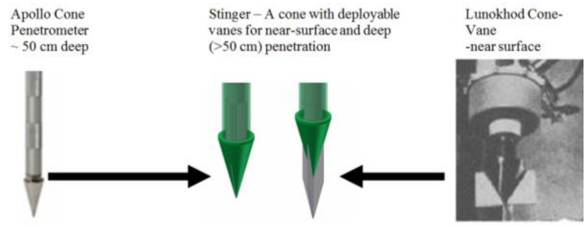

Figure 2. Stinger is a combination of Apollo cone and Lunokhod cone-vane designs.

Stinger tests: We developed a Stinger breadboard (Figure 3) and performed 153 manual tests and 39 Stinger tests in four lunar simulants (JSC-1A, NU-LHT-2M, BP-1, GRC-3) and one Martian simulant MMS. Manual tests used conventional geotechnical tools and ASTM standards.

In all tests, no jamming conditions were witnessed. The Stinger vane easily moved out and back into the cone with no difficulty. The trends in Cone Index as well as shear strength correlate extremely well with density. The values also match results previously reported by NASA, academia, and industry.

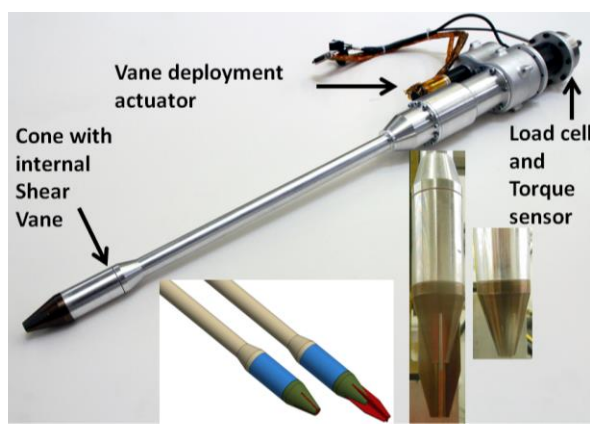

Figure 3. Stinger with its major subsystems.

Next steps: We are currently developing a TRL 6 Stinger. Once complete, the instrument will be integrated and tested on a mobility platform, such as the NASA Ames KREX 2 planetary rover.

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